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# FUEL CELL SUPPORT AND ELECTRICAL INTERCONNECTOR

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<u>Related Cases</u>

This is a Continuation-in-Part of U.S. Application 09/416,554 entitled "Fuel Cell Support And Electrical Interconnector" filed October 12, 1999, commonly assigned to the assignee of the present invention, being incorporated herein in its entirety.

## BACKGROUND OF THE INVENTION

<u>Field of Invention</u>

This invention relates to fuel cell batteries, and, more particularly, to fuel cell batteries requiring refueling of anode material, replacement of anode structures, replacement of cathode structures, and/or electrolyte maintenance.

<u>Description of Related Art</u>

A fuel cell is a device that converts the energy of a fuel (metal, hydrogen, natural gas, methanol, gasoline, etc.) and an oxidant (air or oxygen) into useable electricity. A fuel cell construction generally consists of a fuel supplying electrode (anode) and an oxidant electrode (cathode) separated by an ion conducting medium. A fuel cell stack is comprised of numerous individual cells stacked together to provide the required power. Unlike traditional fossil plants that combust fuels, fuel cells generate electricity through an electrochemical process from which no particulate matter, nitrogen or sulfur oxides (NOx or SOx) are produced. As a result, they do not contribute to the formation of smog and acid rain.

Metal-air fuel cells convert metal fuel (such as zinc or aluminum) and an oxidant (such as air or oxygen) into electricity. Examples of metal-air fuel cells are described in detail in WO99/18628, entitled "Metal-Air Fuel Cell Battery Systems Employing Metal-Fuel Cards", WO99/18627 entitled " Metal-Air Fuel Cell Battery Systems Employing Metal-Fuel Tape", and WO99/18620 entitled " Metal-Air Fuel Cell Battery Systems Employing Moving Anode And

Cathode Structures", US Patent No. 5,250,370, incorporated herein by reference, and other applied science publications well known in the art.

Hydrogen-based fuel cells convert hydrogen fuel and an oxidant (such as air or oxygen into electricity. An example of a hydrogen-based fuel cell is described in WO 99/60642, entitled "Multi-element Fuel Cell System", published May 5, 1999.

Various means have been used for holding the cells in position relative to each other and for electrically interconnecting the cells. Often these means are unrelated and accordingly there is a substantial volumetric loss, excessive complication of elements and overall weight, as well as difficulty in removing and servicing the individual cells. In addition, such fuel cell battery holding structures typically employ an enclosure to house the cells, which renders the enclosed cells difficult to access, replace, or service.

For fuel cells, ease of service is of particular importance because such cells require servicing and replacement of depleted materials in order to work over an extended period of time. More particularly, such cells may require replacement of anode structures, replacement of fuel, replacement of cathode structures and replenishment of electrolyte (or other ionically-conducting medium).

## OBJECT AND SUMMARY OF THE PRESENT INVENTION

It is accordingly an object of the present invention to provide a fuel cell battery device or system with a structure providing integrated fuel cell stacking, mechanical support, and fuel cell electrical interconnection.

It is a further object of the present invention to provide a fuel cell battery device or system which permits quick removal and electrical interconnection of fuel cell elements for service (including replacement of anode structures, replacement of fuel, replacement of cathode structures and replenishment of ionically-conducting medium).

It is yet another object of the present invention to provide a fuel cell battery device or system which includes means for air circulation for use with air depolarized fuel cells.

It is a further object of the present invention to provide a fuel cell battery device or system having a structure that independently and releasably engages each of a plurality of fuel cells to thereby mechanically support the fuel cells so engaged.

It is a further object of the present invention to provide a fuel cell battery device or system having a structure that independently and releasably engages the cathode assemblies and anode assemblies of a plurality of fuel cells to mechanically support the cathode assemblies and anode assemblies so engages, and provide electrical connection to the cathode assemblies and anode assemblies so engaged.

It is a further object of the present invention to provide a fuel cell battery device or system that includes a support structure that independently and releasably engages the cathode assemblies and anode assemblies of a plurality of fuel cells to provide electrical connection to the cathode assemblies and anode assemblies so engaged, and that includes an integrated

interconnection means that can configure the plurality of fuel cells into a desired interconnection arrangement.

It is a further object of the present invention to provide a fuel cell battery device or system that includes a support structure that independently and releasably engages a plurality of fuel cells along one side of the fuel cells, leaving the other sides (e.g., the top and far side of a plate-like fuel cell) exposed for the ready replacement of the anode, cathode, or the ionically-conducting medium of the individual fuel cell disposed therein.

Generally the present invention comprises a fuel cell battery structure comprising at least two fuel cells and an electrical connector block. The fuel cells are electrically interconnected into a battery structure via the connector block. Each fuel cell comprises an anode and cathode element and each of the anode and cathode elements of each cell are provided with a terminal conductor element externally positioned on one side of the respective fuel cells. The connector block comprises a series of conductive elements adapted for electrical and mechanical engagement with the respective terminal conductor elements of the anode and cathode elements of each of the fuel cells on said one side of the respective fuel cells. The connector block further comprises means for electrically connecting the anodes and cathodes of the stacked cells into a desired electrical interconnection. In addition, the block mechanically holds the respective fuel cells on one side of the block, in a fixed position as a result of the mechanical engagement. As a result, another side of each of the fuel cells remains exposed to permit disengagement and removal of the fuel cells from the block.

Generally the present invention comprises means for forming a stack of fuel cells into a unique overall fuel cell (in particular air depolarized cells such as zinc/air cells) or battery system, wherein a single structural element provides means for cell support and stacking and electrical interconnection of the cells into a desired electrical configuration. In addition, the structural element is preferably configured with air duct means to facilitate air circulation to the individual cells, with concomitant increase in discharge rate capability.

In a preferred embodiment of the present invention, flat plate fuel cells and batteries of cells, particularly air-depolarized cells, are stacked and electrically interconnected into a battery system with a connector block and optional support tray. The anode and cathode elements of each cell are provided with terminating elements, preferably extending in a downward "U" shaped configuration from the upper ends of the anode and cathode elements respectively, to provide maximum physical support. However, other extension configurations (e.g., upwardly extending, laterally extending, etc., as well as reversal of the male and female elements) are similarly operable and are included in the present invention.

In a preferred embodiment the connector block comprises a series of conductive apertures, positioned and sized to accommodate the terminal conductor elements of the electrodes therein. The connector block further comprises electrical interconnecting elements to electrically connect the electrodes of the stacked cells in a desired electrical interconnection (serial, parallel and mixed serial and parallel segments). Preferably, male and female plug connections, embedded within apertures in the connector block, are used to mate with the anode and cathode terminating elements of the fuel cells, to effect both the electrical interconnection and mechanical support between the cells and the connector block. The interconnection between anode and cathode terminating elements and the respective apertures further serves to support

and orient the cells in a minimal volume and permits selective rapid cell removal for replacement or servicing. The cells are also preferably provided with keyed members for keyed interlocking with a support tray having co-fitting keying elements to provide full structural integrity for the stacked cells. Lateral end elements extend between the connector block and support tray to complete an open enclosure and provide a support base for air circulating devices, such as fans, in an "air management system" and also support the block in a suspended position suitable for engagement with the individual fuel cells.

## BRIEF DESCRIPTION OF THE DRAWINGS

In order to more fully understand the objects and features of the present invention, the following Detailed Description of the Illustrative Embodiments should be read in conjunction with the accompanying Drawings, wherein:

Figure 1 is a schematic cross section of an exemplary fuel cell (e.g., metal-air fuel cell) in which the present invention can be embodied.

Figure 2 is an exploded side view of the cell of Figure 1 shown with respective anode and cathode current collectors and external connective elements relative to a connector block according to an illustrative embodiment of the present invention.

Figure 3 is an isometric view of the fuel cell of Figure 1 and 2 showing the relative positions of anode terminating elements and cathode terminating elements according to an illustrative embodiment of the present invention.

Figure 4 is an isometric view of two connector blocks of the present invention adjacently aligned, with supporting end elements having air circulation fans according to an illustrative embodiment of the present invention.

Figure 5 is an isometric view of fuel cells stacked on a connector block and positioning tray according to an illustrative embodiment of the present invention.

Figure 6 is a schematic top view of the fuel cells of Figure 5 in a completed stack, showing air flow direction, according to an illustrative embodiment of the present invention.

Figure 7 is a cross section of the connector block with male and female plug connection elements according to an illustrative embodiment of the present invention.

Figure 8a is a bottom view of bus bars showing connections of successive cell anodes and cathodes in a serial cell connection arrangement according to an illustrative embodiment of the present invention.

Figure 8b is a sectioned side view of a bus bar as used in Figure 8a.

Figures 9a and 9b depict alternative configurational extensions of the connection elements of the electrodes according to the present invention.

Figure 10 is a schematic view of an anode assembly with an anode terminating element according to an illustrative embodiment of the present invention.

Figure 11 is a schematic view of a cathode assembly with a cathode terminating element according to an illustrative embodiment of the present invention.

Figure 12 is a partial schematic view of a connector block with apertures and plug connectors disposed therein according to an illustrative embodiment of the present invention.

Figure 13 is a partial schematic view of the connector block of Figure 12 having a PC board integrated therein with a switching network that enables selective interconnection of the anodes and cathodes of the cells coupled thereto into a desired electrical interconnection arrangement.



## DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS OF THE PRESENT INVENTION

Referring now to the figures in the accompanying Drawings, the best modes for carrying out the present invention will now be described in great technical detail, wherein like elements are indicated by like reference numbers.

In general, fuel cell battery devices and systems according to the present invention include one or more fuel cells wherein a fuel anode is brought into "ionic-contact" with a cathode structure by way of an ionically-conducting medium (such as an ionically-conducting polymer, an electrolyte gel, or a liquid electrolyte such as KOH or NaOH). An electro-chemical reaction at this interface produces electrical power that is delivered to an electrical power-consuming load device electrically coupled thereto (via an anode terminating element electrically coupled between the anode and the electrical power-consuming load device and a cathode terminating element electrically coupled between the cathode structure and the electrical power-consuming load device). During this electro-chemical reaction, $O_2$ is typically consumed at the cathode-electrolyte interface of the fuel cell. In metal-air fuel cell battery devices and systems, the fuel anode is a metal (such as zinc or aluminum in the form cards, sheets, tape, paste and the like. In hydrogen-based fuel cells, hydrogen is used as the fuel. An exemplary hydrogen-based fuel cell is described in WO 99/60642, entitled "Multi-element Fuel Cell System", published May 5, 1999.

In metal-air fuel cell battery devices and systems, the oxidized metal (such as zinc-oxide or aluminum-oxide) may be recharged by connecting a power-generating source across the interface whereby the reverse electro-chemical reaction converts the oxidized metal into its original form suitable for reuse in power discharging operations. The electro-chemistry upon which such discharging and recharging operations are based is described in WO99/18628, entitled "Metal-Air Fuel Cell Battery Systems Employing Metal-Fuel Cards", WO99/18627 entitled " Metal-Air Fuel Cell Battery Systems Employing Metal-Fuel Tape", and WO99/18620 entitled " Metal-Air Fuel Cell Battery Systems Employing Moving Anode And Cathode Structures", US Patent No. 5,250,370, and other applied science publications well known in the art.

The anode structure (and anode fuel material in metal-air fuel cells) of the fuel cell in such FCB devices and systems has a limited lifetime. After a number of discharge/recharge cycles, a anode replacement operation is required wherein the anode structure (e.g., oxidized metal in a metal-air fuel cell, or anode element in a hydrogen-based fuel cell) is replaced with a new anode structure.

The cathode structure of the fuel cell in FCB devices and systems also have a limited lifetime. In metal-air FCB devices/systems, the cathode structures comprises an oxygen-permeable mesh of inert conductor and a catalyst for reducing oxygen that diffuses through the mesh into the system. Typically, the operational lifetime of the cathode structure in metal-air FCB devices/ systems extends beyond that of a single metal-fuel anode (e.g., 10 to 50 times the operational lifetime), and thus it may be used repeatedly after replacing the corresponding anode. When the operational lifetime of the cathode structure ends, it may be cost effective to replace the "spent" cathode structure.

In addition, the ionically-conducting medium (e.g., electrolyte) of the fuel cell in FCB device/system also has a limited lifetime. After a number of discharge/recharge cycles, a replacement operation is required wherein the consumed ionically-conducting medium (e.g., electrolyte) is replaced with "fresh" ionically-conducting medium for the fuel cell in the FCB device/system.

According to the present invention, a fuel cell battery device (or system) includes a plurality of distinct fuel cells and a connector block that independently and releasably engages each of the plurality of fuel cells to thereby mechanically support fuel cells that are engaged by the connector block.

In the preferred embodiment of the present invention, the connector block has a plurality of engagement elements (e.g., plug connectors), corresponding to the cathodes and anodes of the plurality of fuel cells, that serve two functions. First, the engagement elements independently and releasably engage the corresponding cathodes and anodes to provide mechanical support to the fuel cells that are engaged by the connector block. Second, the engagement elements provide electrical connection to the cathode terminating element and anode terminating element of the corresponding cathode and anode.

Preferably, the connector block includes an integrated interconnection means, electrically coupled to the cathode terminating elements and anode terminating elements of the plurality of fuel cells, that is used to configure the plurality of fuel cells into a desired interconnection arrangement. Such features shorten the current collection path and reduces loses, thereby enabling high current system designs (e.g., in excess of 25 Amperes).

Moreover, the connector block preferably engages the plurality of fuel cells along one side of the fuel cells, leaving the other sides (e.g., the top and far side of a plate-like fuel cell) exposed for the ready replacement of the anode, cathode, or the ionically-conducting medium of the individual fuel cell disposed therein. Such features provide a compact, lightweight design that has simple, efficient, and user-friendly maintenance operations, suitable for use by consumers in diverse applications.

The connector block is preferably comprised of an electrically insulating material, such as structurally strong engineering plastic (whereby conductive connectors or buses are used to selectively make the appropriate circuits) and is preferably structured in an elongated laterally stepped configuration with a central raised section and peripheral lower sections (for fuel cells of the same dimension it is preferred that the outer sections be on a single plane). In a preferred embodiment, the central section is provided with two rows of apertures wherein each row accommodates anode connectors from fuel cells positioned on either side of the elongated block, and the outer lower sections are provided with single rows of apertures to accommodate connectors from the cathodes of the adjacent cells (it is of course understood that the anode and cathode connections with the block can be reversed without departing from the scope of the invention). Preferably, the anode connectors connected to a given row of apertures are aligned with one another along the row, and the cathode connectors connected to a given row of apertures are aligned with one another along the row; with the respective anode and cathode connectors being offset from each other (differing height relative to the cells and differing extending length (relative to the block) whereby proper connection of anodes and cathodes with the block is assured.

The connector block longitudinally extends for a length at least sufficient to engage the desired number of fuel cells. The height of the block is preferably minimized to be sufficient to mechanically buttress the adjacently held fuel cells while avoiding blocking intercell areas such that air circulation is not hindered in such intercell areas.

In a preferred embodiment, current collecting elements (which preferably extend along the width of the anode and the length of the cathode) are electrically engaged (such as by a conductive threaded engagement) with the respective banana plug connectors. Female conductive sockets are embedded within the connector block and comprise conductive elements which extend to the underside of the block (distal to the engagement with the cells) for selective electrical interconnection.

In a preferred embodiment of the present invention, the connector block is provided with end support members to maintain it in the elevated position for engagement with the collector plugs of the cell electrodes. Moreover, at least one fan is preferably integrated with one or more of these end support members, and is aligned with the longitudinal spacing between the laterally positioned cells. This configuration provides a central air duct for forced guiding of air to the air depolarized cells and then outwardly across the width of the cells. As a result, air is efficiently provided to the individual cells for the air depolarization thereof with high rate capability.

A bottom tray serves to prevent skewing of the cells if they are moved and to ensure proper placement with keyed element engagement between elements of the cells and the tray. The downward U-shaped engagement is preferred in this regard since it readily permits upward disengagement with both the block and the tray in a single motion.

In a metal-air FCB device/system according to the present invention, a liquid electrolyte (such as a potassium or sodium hydroxide solution) may be used as the ionically-conducting medium of the metal-air FCB cells. In such devices/systems, a substantially-transparent window in the wall of the fuel cell structure housing the liquid electrolyte is preferably provided to enable visual monitoring of level of the liquid electrolyte for the given fuel cell. Preferably, this

substantially transparent window is located in an wall of the metal-air FCB cell such that it remains visible when the fuel cells are arranged in a stacked-structure as described herein.

Figure 1 is a schematic cross-section of an exemplary fuel cell (e.g., plate-like metal-air fuel cell) in which the present invention can be embodied. The fuel cell 1 includes a central anode plate 2 comprising a metal-fuel (such as zinc or aluminum) and a handle 9 having an anode current collector 2a disposed therein. The handle 9 supports an anode terminating element 2c as shown in Figures 2 and 3 that terminates the anode current collector 2a. The anode plate 2 is slidably positioned between cathode structures 3a and 3b, which are preferably separated from one another by separators 4a and 4b as shown.

As shown in Figures 2 and 3, the cathode structures 3a and 3b serve as two side walls of an enclosure 1a that also includes side walls 6a and 6b, a top wall 5 and an end wall 5a, which are preferably formed from a strong engineering plastic). In addition, the cathode structures 3a and 3b are electrically coupled to a cathode current collector 3c, which is preferably integrated into one of the side walls of the enclosure 1a and which terminates in a cathode terminating element 3d. The top wall 5 of the enclosure 1a supports the cathode terminating element 3d and preferably separates and electrically insulates the respective anode and cathode current collectors.



The anode 2 is slidably inserted into the enclosure 1a through an opening 8 in the top wall 5 of the enclosure 1a. The electrolyte 6 is fully contained within the enclosure 1a and is disposed between the cathode structures 3a and 3b and the anode plate 2 (when inserted into the enclosure 1a). An O-ring 7 provides a seal when the anode plate 2 is properly inserted into the enclosure 1a.

Figures 2, 3 and 4 are schematic illustrations of an illustrative embodiment of the present invention wherein the exemplary fuel cell of Figure 1 is releasably engaged by a connector block 20 that serve two functions: First, it provides mechanical support for the fuel cell so engaged, Second, it provides for electrical connection to the cathode terminating elements and anode terminating elements of the fuel cells so engaged.

As shown in Figure 2, the anode current collector 2a (which preferably extends across the upper width of the handle 9) terminates in downwardly extending anode terminating element 2c (e.g., conductive plug ) for insertion into mating aperture 22c in the connector block 20. As shown in Figure 10, the anode terminating element 2c preferably comprises a plug connector seated into a bore 11a in the handle 9, and electrically coupled to the anode current collector 2a. . In such a configuration, the weight of the anode (i.e., the gravitational forces resulting therefrom) is used to maintain the engagement of the anode terminating element 2c into the corresponding mating aperture 22c in the connector block 20.

As shown in Figure 2 and 3, cathode current collector 3c (which preferably extends along an outer longitudinal edge of the cell as shown ) terminates in a downwardly extending cathode terminating element 3d (e.g., conductive plug) for insertion into mating aperture 23c in the connector block 20. As shown in Figure 11, the cathode terminating element 3d preferably comprises a plug connector seated into a bore 11b in the top wall 5 of the enclosure 1a, and electrically coupled to the cathode current collector 3c. In such a configuration, the weight of the cathode (i.e., the gravitational forces resulting therefrom) is used to maintain the engagement of

the cathode terminating element 3d into the corresponding mating aperture 23c in the connector block 20.

As shown in Figure 12, the connector block 20 includes apertures 22c and 23c that contain electrical connecting elements that connect to the anode terminating elements 2c and cathode terminating elements 3d inserted therein. Preferably, the apertures 22c and 23d comprise plug connectors 30a and 30b seated into bores 11c and 11d, respectively, in the connector block 20. When the anode terminating element 2c and cathode terminating element 3d are inserted and engaged by the apertures 22c and 23c (and the electrical connecting elements contained therein), the connector block 20 provides mechanical support for the fuel cell so engaged, and also provides for electrical connection to the cathode terminating elements and anode terminating elements of the fuel cells so engaged.

Figure 4 is an isometric view of two connector blocks 20 of the present invention adjacently aligned. Each connector block 20 has a central raised section 20a and outer peripheral ledges 20b and 20c. Two rows of apertures 22c and 22c' are disposed in raised section 20a and contain plugs 30 which slidably engage the anode terminating elements 2c of cells positioned on both lateral sides of block 20 as shown in Figure 5. Similarly, two rows of apertures 22c and 22c' are disposed in outer peripheral ledges 20b and 20c, respectively, and contain plugs 30 which slidably engage the cathode terminating elements 2c of cells positioned on both lateral sides of block 20 as shown in Figure 5.

In addition, Figures 4, 5 and 6 illustrates the connector block 20 with supporting end elements having air circulation fans according to an illustrative embodiment of the present invention. Figure 4 illustrates two abutting connector block assemblies each includes end support members 25 integrated with the ends of a connector block 20 (such as with a bolted connection and such support members maintain the block in the elevated position for engagement with the respective fuel cells). In addition, the support members 25 include fans 28 (powered by the cells themselves or from an external source) integrated therein which force air into the cells and against all the respective cell cathodes as shown in Figure 6 (the arrows indicate air flow direction). As seen in Figure 5, engagement between the fuel cells 1 and the block 20 forms a central open air duct 50 beneath the block 20 which is closed at both ends by the support member 25. The fans 28 blow air into the air duct 50, which is then forced out laterally between the fuel cells and against the cathode elements for maximized air contact and depolarization as illustrated in Figure 6.

As shown in Figure 3, a wall (for example, the end wall 5a as shown) of the fuel cell 1 preferably includes a key aperture 40, which is adapted to engage keyed protrusion 41 in supporting battery tray 45. As a result, each fuel cell 1 is preferably held on three sides: on the upper end by engagement of the block 20 with the respective plug connectors, with a buttress against the inner edges of the cells between the block 20, and the cathode current collector and by the keyed connection at the base. All three connections are readily disengaged by a lifting of the individual cells off the connector block.

As also shown in Figure 5, each fuel cell 1 is provided with a window 9 at the appropriate electrolyte level whereby decrease in electrolyte level is readily apparent.

Figures 7, 8, and 13 are schematic representations of exemplary embodiments of the connector block 20 according to the present invention, wherein the connector block 20 includes an integral interconnection means for electrically connecting the anodes and cathodes of the stacked cells into a desired electrical interconnection. As seen in Figure 7, block 20 is cored with through holes 22c and 23c into which female plugs 30 are seated. The female plugs have a receptacle core for engagement with the mating plugs 3d (which are electrically connected to the cathode terminating elements for the fuel cells releasably engaged by the connector block 20) or mating plugs 2c (which are electrically connected to the anode terminating elements for the fuel cells releasably engaged by the connector block 20). In addition, the female plugs have conductive ends (as shown, such ends are threaded), for external engagement, at the bottom of the connector block 20, with interconnection devices.

Figures 8a and 8b illustrate an exemplary embodiment for interconnecting the anode and cathodes of the fuel cells engaged with the connector block 20 wherein a portion of the underside of block 20 is shown with interconnector elements 28 providing successive connection engagement of anodes and cathode elements of adjacent cells in a serial connection. As further shown in Figure 8b the interconnector elements 28 are bus bars with two apertures 28a and 28b for engagement with the extending ends of the female plugs in connector block 20. The arrangement of interconnector elements 28 enables the electrical connection of the anodes and cathodes of the stacked cells into a desired electrical interconnection arrangement (serial, parallel and mixed serial and parallel segments).

Figure 13 illustrates another exemplary embodiment for interconnecting the anode and cathodes of the fuel cells engaged with the connector block 20. In this embodiment, a printed circuit (PC) board 61 includes a plurality of receptacles 62a that mate with the ends of the anode plug connectors 30a that extend from the underside of the connecting block 20, and a plurality of receptacles 62b that mate with the ends of the cathode plug connectors 30b that extend from the underside of the connecting block 20. In addition, the PC board includes a switching network, coupled to the receptacles and to output terminals 64, that operates in response to control signals communicated from a controller (not shown) via a control port 66, to selectively electrically-couple together the receptacles, and to selectively electrically-couple one or more receptacles to the output terminals 64, to thereby provide for interconnection of the anodes and cathodes of the stacked cells into a desired electrical interconnection arrangement (serial, parallel and mixed serial and parallel segments) for output to the terminals 64.

In other embodiments, as shown in Figures 9a and 9b, the electrode plug elements are shown to extend upwardly and laterally respectively. In such embodiments, the connector block (not shown) is correspondingly apertured. Similarly, the male and female plugs may be reversed, though with some complication in the connecting structure.

It should be understood that the illustrative embodiments set forth above describing metal-air FCB devices (and systems) of the present invention can be readily modified and adapted to apply to any arbitrary type of fuel cell, including hydrogen-based fuel cells. More particularly, in hydrogen-based fuel cell, the anode typically comprises a hydrogen supply structure that leads to a membrane that permits hydrogen ions to pass through into the ionically-conducting medium. In such systems, replacement of the anode structure typically involves replacement of this membrane, and possibly replacement of this hydrogen supply structure.

It is understood that the above embodiment and discussion are illustrative of the present invention and descriptions therein are not be construed as limitations on the present invention. It is understood that changes in components, structures, materials, cell types and the like may be made without departing from the scope of the present invention as defined in the following claims.